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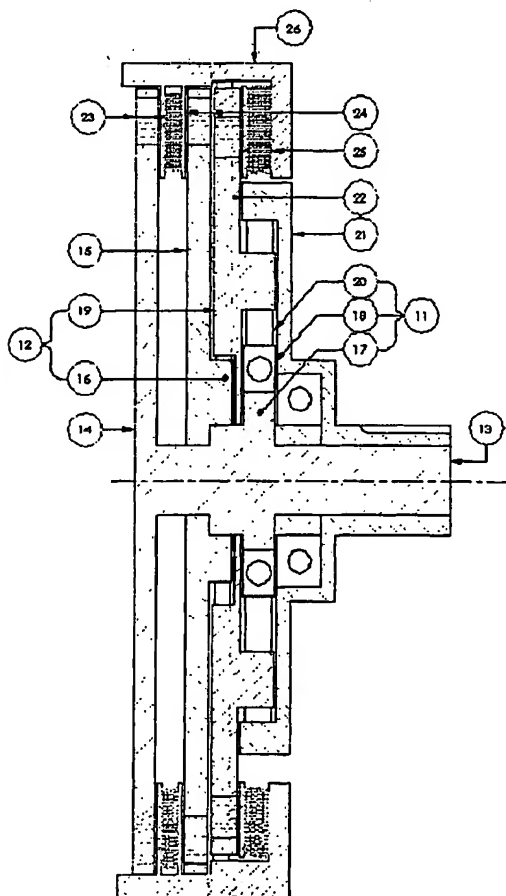
(57) Abstract: A variable ratio transmission having an input (14) and an output (21) and being of the epicyclic type involving a sun element (17, 16)), a ring element (21) and a planet carrier element (22) in each of at least first (11) and second (12) unequal co-axial epicyclic assemblies, a second rotating element (22) of the first assembly (11) and a second rotating element (22) of the second assembly (12) being constrained to rotate at a common angular velocity, and control means (25) for progessively changing the gear ratio applied to a load connected to the first rotating element (21) of the first assembly (11), characterised in that the first rotating elements (21) are unequal pairs of the same mechanical elements of the respective assemblies (11, 12) and in conjunction with respective second rotating elements (22) each represents different respective fixed gear ratios relative to the input (14) and the output (21) of the transmission, the second rotating elements (22) are unequal pairs of the same mechanical elements of the respective assemblies (11, 12) and in conjunction respective said first rotating elements (21), each represents fixed gear ratios between the input (14) and output (21), the control means (23, 25) operable to progressively increase or decrease the output gear ratio as operation demands.

VARIABLE RATIO MULTI-GEAR

TECHNICAL FIELD OF THE INVENTION

This invention relates to a variable speed transmission of the epicyclic type.

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BACKGROUND TO THE INVENTION

Epicyclic gear trains, also referred to as planetary gear trains, are those in which one or more gear elements orbit about the central axis of the train. Thus, they differ from an ordinary train by having a moving axis or axes. The trains involve the

10 interaction of three mechanically distinct rotating elements, namely a sun-element, a ring-element and a planet-carrier-element. The planet-carrier-element being a link that mounts one or more planet elements.

Epicyclic gear trains are, fundamentally, two-degree-of-freedom systems. Therefore, two inputs are required before they can be uniquely analysed. Quite

15 frequently a fixed gear is included in the train. Its angular velocity is zero, but this zero value constitutes one of the input values. Any sun-element, ring-element or planet carrier-element can serve as an input or output.

The equation for Power is:

$P = T * \omega$

20   Where P = Power

             T = Torque

            ω = angular velocity

The power through any of the rotating elements of the epicyclic gear train therefore is proportional to the torque and angular velocity of the element. Power is

25 conserved through any system meaning that the power into a system equals the power out of that system. Some of the energy transferred through the system may be dissipated or stored as non-useful energy and therefore the useful power output from a system may be different to the power into the system.

If an epicyclic train with one of the degrees-of-freedom constrained from rotating has the resistive torque acting on its output reduced, and the input power remains the same, the speed of the output will increase. The power in equals the power out and assuming that the dissipative power is small relative to the input

5   power, the useful power out will be similar to the power in. The fixed ratio of output to input means that a change of torque at the output means a changed torque requirement at the input. If the input power is constant then if one of either the input torque or angular velocity changes then the other will adjust also. So the input angular velocity increases so that the product of the input torque and angular velocity

10   remains the same. If further the input angular velocity remains constant, then as the resistive torque acting on the output is reduced further, the element constrained from rotation can be released and the power not used at the input can be diverted to that element in such a way that it uses the power to increase its speed and therefore increase the output speed.

15   An object of the present invention is to use the balancing of power discussed above to provide a variable speed transmission of the epicyclic type as a useful alternative to the prior art.

OUTLINE OF THE INVENTION

20   This invention relates to devices for the transmission of mechanical power, in the form of rotational motion. In particular, it is directed to the transmission of power between one or more motive sources and one or more resistive torques (loads) to provide a device which can provide, in a preferred form, continuously variable ratios between the angular velocity at an output to the angular velocity of an input. The

25   continuously variable ratios can be selected manually, or in a preferred form automatically by self-regulating means, and can provide variable output angular velocity and variable torque multiplication.

The present invention finds uses in many applications including electronic, hydraulic and mechanical. Examples of similar drives are Australian patents 607822

and 613927 as spin control differentials for vehicles and couplings. Australian patent

607822 protects the use of a double cam, which enables ratios that would not be

practical with the use of a single cam where cycloidal elements are used and the

double cam enables balancing. Australian patent 607822 describes the use of certain

5   types of sprag-clutches. The Australian patent 607822 has been assigned to M.L.S.

Dean. Eaton Corporation has an Australian Patent number 465202 based on a

planetary drive that has a sun gear, a ring gear and a planet carrier. Sumitomo Heavy

Industries Ltd, Japan, under the name "Cyclodrive" manufacture examples of

planetary drives.

10   Although planetary gears are known, the known prior art gears have failed to

take advantage of certain of their features, in particular, the contra-rotational nature of

the input and output shafts being on the same axis. This invention optionally provides

in a one-body transmission a more practical way of supporting the load from one side

than known prior art. It also can provide a continuously variable ratio from one input

15   and can have this variable ratio controlled by a control means that does not

necessarily rely on slippage and has the capabilities of being self-regulating.

The invention is capable of absorbing energy from the load connected too an

output or supplying energy to an output, thus providing regenerative braking or

acceleration according to an output power demand.

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In one aspect the invention provides a variable speed transmission having at

least one input and at least one output and being of the epicyclic type using toothed

gearing or preferably cycloidal arrangements involving interaction of three

mechanically distinct rotating elements, namely a sun element, a ring element and a

25   planet carrier element in each of at least first and second unequal co-axial epicyclic

assemblies, a first rotating element of the first assembly free to rotate and a first

rotating element of the second assembly constrained to rotate at a controlled angular

velocity relative to a fixed frame of reference , a second rotating element of the first

assembly and a second rotating element of the second assembly being constrained

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to rotate at a common angular velocity, and control means for progressively changing

the gear ratio applied to a load connected the first rotating element of the first

assembly of the Variable Ratio Multi-gear characterised in that the first rotating

elements are unequal pairs of the same mechanical elements of the respective

5   assemblies and in conjunction with respective second rotating elements each

represent different respective fixed gear ratios relative to the input and the output of

the Variable Ratio Multi-gear, the second rotating elements are unequal pairs of the

same mechanical elements of the respective assemblies and in conjunction with

respective said first rotating elements each represent fixed gear ratios between the

10   input and the output of the Variable Ratio Multi-gear, a third element of the second

assembly rotating at a controlled angular velocity,the control means being operative

to progressively increase or decrease the output gear ratio automatically in

accordance with the demand.

        In the description "output higher gear stage of operation" means "higher" in

15   the sense of a gear ratio approaching 1:1 ratio as input to output, while "output low

gear stage of operation" means an output gearing in the opposite sense generally

corresponding to a lower output angular velocity.

        The first rotating elements are typically the ring elements of the respective

assemblies. The ring elements are preferably outer bodies having spaced endless

20   scallop guides, each scallop guide having a relatively unequal number of scallops to

rollers in either side depending on the required gear ratios for a particular application

and the guides being adapted to receive sets of planet rollers of the planet carrier

elements.

        The second rotating elements are typically the planet carrier elements of the

25   respective assemblies. The planet carrier elements are typically formed as an integral

unit housing spaced sets of rollers with relatively unequal numbers relative to the

number of scallops, with the rollers corresponding to the planets of each assembly,

the rollers bridging between the scallop guides of the outer bodies and the third

elements of the assemblies. The planet carrier is preferably constrained by a rotation

blocking means to travel in one direction only. The rotation blocking means is preferably a selective rotation blocking means enabling selection of rotation of the second rotating elements in forward or reverse direction. The rotation blocking means may in some applications be allowed to rotate at a controlled angular velocity in the

5   direction that it is blocking to enable a further reduced output low gear stage of operation.

The third elements of the assemblies are typically sun elements in the form of respective cams, with at least one cam and in practical terms both cams typically having a roller bearing or bush assembly separating the cam into an inner cam and a

10   cam ring able to travel opposite the direction of the inner cam.

The control means can be any means that enables a variable rotation to be supplied to the third element of the second assembly across a continuous range of output gear ratios between zero and a speed that causes the planet carrier element angular velocity to equal the angular velocity of the third element of the first

15   assembly.

Modules made up of the first and second assemblies can be employed in various arrangements with various inputs and outputs and connections between modules for various applications. What is common is that each of the first and second assemblies of each module share a common planet element, the first element of the first

20   assembly is connected to the load directly or to another module and the first element of the second assembly has its angular velocity controlled relative to a fixed frame of reference which the angular velocity for some applications will be zero relative to a fixed frame of reference, the third element of the second assembly has its angular velocity controlled relative to the third element of the first assembly and may vary or

25   not vary proportionally to the angular velocity of the third element of the first assembly. The control of the angular velocity of the first element of the second assembly relative to a fixed frame of reference can be done by a plethora of means including hydraulics with the displaced hydraulic fluid being directed so as to use the power in the fluid to add to the input power.

In practice for some applications there may need to be a braking system that connects the first element of the first assembly to the third element of the first assembly or directly to the input to stop an overrun situation where the input angular velocity to the third element of the first assembly has been reduced and the inertia of 5   elements connected to the first element of the first assembly needs to be controlled.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 has been given as an illustrative example of the present invention and many variations and modifications thereto will be apparent to those skilled in the 10   art without departing from the broad ambit and scope of the invention as herein set out in the appended claims. Figure 1 is a variation indicated in the diagram previously labelled Figure 4A. The variations of Figure 4A were indicated by the element numbering system. The following table shows the correlation between the element numbers in Figure 1 and those in the diagram previously labelled Figure 4A.

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Figure 4A Element	Figure 1 Element	Description
1	13	Input shaft
3a	17	Cam – Sun Element
3b	16	Cam – Sun Element
5b	21	Body (Output) – Ring Element (scallops are indicated as 9 in Figure 4A)
5c	26	Body – Ring Element (scallops are indicated as 9 in Figure 4A)
14	14	Rotor
15	15	Rotor
D6	22	Cage - Combined Carrier Element for assemblies 11 and 12.

METHOD OF PERFORMANCE

In the example illustrated in Figure 1, the module employs first and second unequal co-axial epicyclic assemblies (11) and (12), these are both of the cycloidal type, that is, employing scallops and rollers.

Modules employed will vary in specific arrangement for other applications. What is common is that each of the assemblies (11) and (12) share a common planet element. The sun elements are separate cams, rollers bridge between the cams and the scallops. The planet element comprises a planet carrier bridging axially between the assemblies having opposite sides which are relatively unequal in terms of the number of rollers to the number of scallops carried by the planet carrier, while the ring element comprises an outer body having scallops arranged so the assemblies each represent different fixed ratios relative to an input and an output.

This means the planet carriers of the two assemblies are constrained to rotate at the same angular velocity. In the illustrated embodiment the angular velocity of the output (21) could be zero.

In each assembly the cams are eccentric cams which rotate in co-operation with the scallops and roller configuration of the respective assemblies. One of the cams is driven by an input shaft, this will cause the output, that is the outer body, to rotate while the other cam rotates according to a variable ratio which may be connected to the same input as the other cam. The output gear ratio is influenced by the angular velocity of the second cam, thus various arrangements for applying a variable ratio to the second cam will influence the output in a controllable fashion according to demand.

While the above description deals with the general features involved, the following description will enable understanding of the application of the invention to the specific application of Figure 1.

Figure 1 shows a Variable Ratio Multi-gear multi-gear according to the invention an input, which is a rotor (14) an output (21) and electrical coil and

permanent magnet arrangements (23 – 25) that apply torques respectively to rotors (14, 15) and a planet element in the form of a cage (22).

Items (23), (24) and (25) are arrangements of permanent magnets and electrical coils so that with electricity flowing through the coils, interacting magnetic fields are produced which cause a torque on the rotors (14), (15) and cage (22) respectively. The electricity supply can be adjusted individually for each of items (23) to (25). The electrical coil and permanent magnet arrangements (23 – 25) could be replaced by any type of motive sources and could be connected to the cams (16) and (17) in a plethora of ways.

The body (26) can be split at the dashed vertical dashed line (shown at the top and bottom of body (26)) and the left part of body (26) held relative to a fixed frame of reference and the right part being constrained to rotate about the same axis as cams (16) and (17) at a controlled angular velocity relative to the left part of body (26). The body (26) would be most likely split as described above in an arrangement where the input to cam (16) was constant or fixed at a constant ratio to the angular velocity of cam (17). In the following example the body (26) is not split and the whole of body (26) is held relative to a fixed frame of reference.

The rotor (14) and input shaft (13) are combined as an integrated part in this module. As an alternative, the rotor (14) could be removed and the input could be solely from an external motive source driving the input shaft (13). The point is the module comprising the groupings (11) and (12) remains the same.

Assembly (11) is the first unequal coaxial assembly and comprises of a cam {sun-element} (17), bearing (18) and rollers {planet-element} (20). The cam (17) is fixed to the input shaft (13), which is therefore fixed to the input. The bearing (18) has an inner sleeve fitted to the outer diameter of the cam (17). The bearing has an outer sleeve, the outer sleeve of the bearing (18) makes contact with the rollers (20). As the input rotates, the cam (17) causes the bearing (18) to move in an eccentric fashion. This causes the rollers (20) to be cyclically displaced away and towards the central axis of the Variable Ratio Multi-gear, the total displacement relative to this

central axis, being twice the cam axis offset from this axis. The rollers (20) are

located in equally spaced guides in the cage {planet element} (22). The rollers (20)

make contact with scallops in the output {ring element}(21). For both assemblies (11

& 12), the number of scallops relative to the number rollers in contact with the

5   scallops, determines the direction of rotation it would rotate the cage (22) if the body

the rollers act against, bodies (21) and (26), were held still. One more scallop than

the number of rollers gives a cage rotation direction the opposite to the cam rotation.

One less scallop than the number of rollers would give a cage rotation the same as

the cam rotation. The scallops are so shaped that as the rollers are acted on by the

10   cam, the scallops rotate relative to the cage at a constant angular velocity ratio to that

of the cam. The action between the cam (17), bearing (18) and rollers (20) against

the output (21), causes an equal and opposite reaction on the cage (22), tending to

rotate it in the opposite direction to the rotation of the output (21). The cage (22) is

constrained by a rotation blocking means (not shown) in such a way as to allow the

15   cage (22) to only rotate in a direction the same as the output (21) and optionally at a

controlled angular velocity in the direction that it is blocking. Therefore because of the

reactive forces, the cage (22) will be held against the rotation blocking means with

just the actions of assembly (11) alone. The magnetic effects caused by items (25)

can drive the cage (22) (with the same action as (23) does on item (14)). The torque

20   caused by items (25) would need to be higher relative to the torque required at the

cams (16) and (17) and so is an ancillary action and not necessary for the central

concept of the present invention although it may be necessary for some applications

to include it. The rollers will rotate about there own axis as they move in relation to

the scallops. The bearing (18), is added to eliminate the sliding action of roller (20)

25   against cam (17), which would occur (if they were in direct contact) because of the

difference in the direction of there angular rotations. The output (21) is constrained to

rotate about the central axis of the input shaft (13). The cyclical movement of the

rollers (20) acting on the scallops alone, causes the output (21) to rotate at a reduced

rotational speed depending on the number of rollers and scallops.

For example, if the cage (22) is constrained from being able to rotate, and if assembly 11 has four rollers (20), and there are five scallops in the output (21), the ratio would be one output (21) revolution for every five revolutions of the cam (17) with the output (21) rotating in the same direction as the cam (17). If the output (21) was held and the cage (22) free to rotate, the ratio would be one cage (22) rotation for every four of the cam (16) in the opposite direction of rotation to cam (16). The rotation blocking means discussed above would normally block this rotation although the direction that is blocked will have to be changed to allow reversing or other functions.

Assembly (12) is the second unequal coaxial assembly and comprises of a cam (16), and rollers (19). The scallops in the output (21) make contact with the rollers (19) which make contact with the cam (16). The cam (16) is fixed to the rotor (15). The rotor (15) drives cam (16) through the action of the magnet and coil arrangement (24). A bearing could be optionally fitted to the outside diameter of the cam (16). The relative number of scallops and rollers for assembly (12) are different to the numbers for assembly (11). The rollers are located in equally spaced guides in the cage (22). The cage therefore bridges axially between assemblies (11) and (12) and the rollers (19) are constrained to rotate at the same angular velocity about the central axis of the input shaft (13) as the rollers (20) of assembly (11). The numbers of scallops and rollers are such that if the body (26) is constrained from being able to rotate, the action of the cam (16) against the rollers (19) and the consequential rollers (19) against the scallops in body (26) will cause the cage (22) to rotate in the same direction as the cams (16) and (17). The action of cam (17) therefore tries to rotate the cage (22) against the rotation blocking means and cam (16) tries to rotate the cage (22) away from the rotation blocking means.

For example, if the body (26) is constrained from being able to rotate, and the cage (22) free to rotate and if assembly (12) has four rollers (20), and there are three scallops in the body (26) the ratio would be one cage (22) revolution for every four revolutions of the cam (16), with the cage (22) rotating in the same direction as the

cams (16) and (17). This is the same ratio that cam (17) would rotate the cage (22) if the output (21) is constrained from rotating, but in the opposite direction to the action of cam (16). Therefore with the same torque input to both cams (16) & (17) then the torque by cam (17) tending to hold the cage (22) against the rotation blocking means

5   will be balanced by the torque by cam (16) tending to lift the cage (22) away from the rotation blocking means.

        If the assembly (11) cam (17) is caused to rotate, the output (21) will rotate at another angular velocity, being a fixed ratio to the input angular velocity. The assembly (12) cam (16) will rotate at an angular velocity dependent on the input from

10   the magnet and coil arrangement (24), and for the central concept of this arrangement, in the same direction to cam (17). The cam (16) will have no effect on the output angular velocity until the electrical coils of items (24) are activated. With the electrical coils activated, a torque is transmitted through the rotor (15) to the cam (16). The electrical coils could be activated so that the torque acts in the same or

15   opposite direction as the rotation of the cam (17). The torque in this arrangement would act in the same direction as the rotation of the cam (17), the output (21) would rotate at the angular velocity determined by the fixed ratio but with an increased rotation dependent on the amount of rotation contributed by the action of items (24) on cam (16) (via the rotor (15)) onto the cage (22). . It is the rotation of the cage (22)

20   that causes the output to increase its angular velocity relative to the input angular velocity. When the angular velocity of the cage (22) reaches the same angular velocity of cam (17) there is no relative difference in angular velocities between the two, therefore the output (21) will rotate at the same angular velocity as the input (13). Any angular velocity of the cage (22) between zero and the angular velocity of

25   the input will give an angular velocity of the output (21) between a ratio determined by the fixed ratio of assembly (11) and the angular velocity of the input. If the arrangement shown in Figure 1 is operating with the maximum possible power supply to the electrical coils and the input (13) is rotating at a constant angular velocity, then there would need to be a relative reduction in the output (21) resistive torque

(hereafter called the 'load') before the coils of items (24) would be supplied power. With a reduction in load, the torque required by cam (17) reduces because of the fixed ratio of assembly (11). The power required by the coils of items (25) therefore is reduced. When the reduction in load is of a sufficient value that the power not used

5   by the coils of items (25) can be used by the coils of items (24) to provide enough torque to cam (16) to rotate the cage (22) away from the rotation blocking means, then power is supplied to the coils of items (24). The output gear ratio therefore can be progressively decreased from the fixed ratio of the first assembly to a 1:1 ratio by progressively increasing the torque acting on the cam (16) from zero to a value that

10   causes the cage (22) to rotate at the same speed as the input (13). The output torque is inversely proportional to the output angular velocity.

Whilst the above has been given by way of illustrative example of the present invention many variations and modifications thereto will be apparent to those skilled

15   in the art without departing from the broad ambit and scope of the invention as herein set out in the appended claims.

CLAIMS:

1.   A Variable Ratio Multi-gear having an input and an output and being of the

epicyclic type involving interaction of three mechanically distinct rotating elements,

namely a sun element, a ring element and a planet carrier element in each of at least

first and second unequal co-axial epicyclic assemblies, a second rotating element of

the first assembly and a second rotating element of the second assembly being

constrained to rotate at a common angular velocity, and control means for

progressively changing the gear ratio applied to a load connected to the first rotating

element of the first assembly of the Variable Ratio Multi-gear characterised in that the

first rotating elements are unequal pairs of the same mechanical elements of the

respective assemblies and in conjunction with respective second rotating elements

each represent different respective fixed gear ratios relative to the input and the

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output of the Variable Ratio Multi-gear, the second rotating elements are unequal pairs of the same mechanical elements of the respective assemblies and in conjunction with respective said first rotating elements each represent fixed gear ratios between the input and the output of the Variable Ratio Multi-gear, the control

5   means being operative to progressively increase or decrease the output gear ratio in accordance with the demand for an output lower or higher gear stage of operation.

2.   The Variable Ratio Multi-gear according to claim 1 wherein the first rotating elements are the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides, each scallop guide having

10   unequal numbers of scallops and the guides being adapted to receive sets of planet rollers of the planet carrier elements, the second rotating elements being planet carrier elements of the respective assemblies, the planet carrier elements housing spaced sets of rollers of unequal numbers of rollers corresponding to the planets of each assembly, the rollers bridging between the scallop guides of the outer bodies

15   and the third elements of the assemblies, the planet carrier elements being constrained by a rotation blocking means allowing rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements in the form of respective cams.

3.   The Variable Ratio Multi-gear according to claim 1 wherein the first rotating

20   elements are the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides, each scallop guide having unequal numbers of scallops and the guides being adapted to receive sets of planet rollers of the planet carrier elements, the second rotating elements being planet carrier elements of the respective assemblies, the planet carrier elements housing

25   spaced sets of rollers of unequal numbers of rollers corresponding to the planets of each assembly, the rollers bridging between the scallop guides of the outer bodies and the third elements of the assemblies, the planet carrier elements being constrained by a rotation blocking means allowing rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being

sun elements in the form of respective cams, the control means being operable to supply a variable rotation to the third element of the second assembly across a continuous range of output gear ratios between low and high angular velocities at respective predetermined low and high output angular velocities.

5   4.   The Variable Ratio Multi-gear according to claim 1 wherein the first rotating elements are the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides, each scallop guide having unequal numbers of scallops and the guides being adapted to receive sets of planet rollers of the planet carrier elements, the first rotating element of the second

10   assembly constrained to a fixed frame of reference, the second rotating elements being planet carrier elements of the respective assemblies, the planet carrier elements housing spaced sets of rollers of unequal numbers of rollers corresponding to the planets of each assembly, the rollers bridging between the scallop guides of the outer bodies and the third elements of the assemblies, the planet carrier elements

15   being constrained by a rotation blocking means allowing rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements in the form of respective cams, a third element of the second assembly rotating at a controlled angular velocity the control means being operative to progressively increase or decrease the output gear ratio in accordance with the

20   demand for an output lower or higher gear stage of operation.

       5.   The Variable Ratio Multi-gear according to claim 1 wherein the first rotating elements are the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides, each scallop guide having unequal numbers of scallops and the guides being adapted to receive sets of planet

25   rollers of the planet carrier elements, the second rotating elements being planet carrier elements of the respective assemblies, the planet carrier elements housing spaced sets of rollers of unequal numbers of rollers corresponding to the planets of each assembly, the rollers bridging between the scallop guides of the outer bodies and the third elements of the assemblies, the planet carrier elements being

constrained by a rotation blocking means allowing rotation in one direction and a

controlled rotation in the other direction, the third elements of the assemblies being

sun elements in the form of respective cams, the third element of the second element

assembly being constrained to rotate at a respective fixed gear ratio relative to an

5   input to the Variable Ratio Multi-gear, the control means being operable to supply a

variable rotation to the first element of the second assembly across a continuous

range of output gear ratios between low and high angular velocities at respective

predetermined low and high output angular velocities.

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AMENDED CLAIMS

1.   A Variable Ratio Multi-gear having at least one input and one output and being of

the epicyclic type involving interaction of three mechanically distinct rotating elements

with any suitable form that allows the transfer of torque between input and output,

5   namely a sun element, a ring element and a planet element in each of at least first

and second unequal co-axial epicyclic assemblies, a first element of the first

assembly and a first element of the second assembly able to rotate independently, a

second rotating element of the first assembly and a second rotating element of the

second assembly being constrained to rotate at a common angular velocity, a third

10   element of the first assembly being connected to a motive source, and control means

for progressively changing the gear ratio applied to a load connected to the first

element of the first assembly of the Variable Ratio Multi-gear characterised in that the

first and second assemblies each represent unequal fixed gear ratios respectively

between the input and the output of the Variable Ratio Multi-gear, the first and

15   second assemblies arranged so that if individually each assembly has their first

element constrained and their third element rotated in a certain direction the second

element will tend to rotate in an opposite direction relative to the tendency of the

other assembly, the control means being operative to progressively increase or

decrease the output gear ratio in accordance with the demand for an output lower or

20   higher gear stage of operation.

2.   The Variable Ratio Multi-gear according to claim 1 wherein the first elements

are the ring elements of the respective assemblies, the ring elements being outer

bodies having spaced endless scallop guides being adapted to receive sets of planet

elements being in the form of rollers, the second rotating elements comprising of

25   planet carrier elements and planet elements, the planet carrier elements of the

respective assemblies constrained to rotate about an axis collinear with the axes of

their respective third elements, the planet carrier elements locating and controlling

the motion of integral spaced sets of rollers corresponding to the planet elements of

each assembly, the rollers bridging between the scallop guides of the outer bodies

and the third elements of the assemblies, the planet carrier elements being

constrained by a rotation controlling means allowing free rotation in one direction and

a controlled rotation in the other direction, the third elements of the assemblies being

5   sun elements in the form of respective cams.

3.   The Variable Ratio Multi-gear according to claim 1 wherein the first elements

are the ring elements of the respective assemblies, the second rotating elements

comprising of planet carrier elements and planet elements, the planet carrier

elements of the respective assemblies constrained to rotate about an axis collinear

10   with the axes of their respective third elements, the planet elements constrained to

rotate on their own axes with the axes being constrained to rotate with the planet

carrier element, the planet elements with their axes offset from their respective planet

carrier element so as to bridge individually or in combination with other planet

elements between the ring element and the third element of their respective

15   assembly, the planet carrier elements being constrained by a rotation controlling

means allowing free rotation in one direction and a controlled rotation in the other

direction, the third elements of the assemblies being sun elements, the ring and

planet and sun elements being in a form that will allow the transfer of torque at a fixed

ratio between elements.

20   4.   The Variable Ratio Multi-gear according to claim 2 wherein the first elements are

the ring elements of the respective assemblies, the ring elements being outer bodies

having spaced endless scallop guides being adapted to receive sets of planet

elements being in the form of rollers, the second rotating elements comprising of

planet carrier elements and planet elements, the planet carrier elements of the

25   respective assemblies constrained to rotate about an axis collinear with the axes of

their respective third elements, the planet carrier elements locating and controlling

the motion of integral spaced sets of rollers corresponding to the planet elements of

each assembly, the rollers bridging between the scallop guides of the outer bodies

and the third elements of the assemblies, the planet carrier elements being

constrained by a rotation controlling means allowing free rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements in the form of respective cams, the control means being operable to supply a variable rotation to the third element of the second assembly across a

5   continuous range of output gear ratios between low and high angular velocities at respective predetermined low and high output angular velocities.

5. The Variable Ratio Multi-gear according to claim 3 wherein the first elements are the ring elements of the respective assemblies, the second rotating elements comprising of planet carrier elements and planet elements, the planet carrier

10   elements of the respective assemblies constrained to rotate about an axis collinear with the axes of their respective third elements, the planet elements constrained to rotate on their own axes with the axes being constrained to rotate with the planet carrier element, the planet elements with their axes offset from their respective planet carrier element so as to bridge individually or in combination with other planet

15   elements between the ring element and the third element of their respective assembly, the planet carrier elements being constrained by a rotation controlling means allowing free rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements, the ring and planet and sun elements being in a form that will allow the transfer of torque at a fixed

20   ratio between elements, the control means being operable to supply a variable rotation to the third element of the second assembly across a continuous range of output gear ratios between low and high angular velocities at respective predetermined low and high output angular velocities.

6.   The Variable Ratio Multi-gear according to claim 2 wherein the first elements are

25   the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides being adapted to receive sets of planet elements being in the form of rollers, the second rotating elements comprising of planet carrier elements and planet elements, the planet carrier elements of the respective assemblies constrained to rotate about an axis collinear with the axes of

their respective third elements, the planet carrier elements locating and controlling

the motion of integral spaced sets of rollers corresponding to the planet elements of

each assembly, the rollers bridging between the scallop guides of the outer bodies

and the third elements of the assemblies, the planet carrier elements being

5   constrained by a rotation controlling means allowing free rotation in one direction and

a controlled rotation in the other direction, the third elements of the assemblies being

sun elements in the form of respective cams, the first element of the second

assembly constrained to a fixed frame of reference, a third element of the second

assembly rotating at a controlled angular velocity the control means being operative

10   to progressively increase or decrease the output gear ratio in accordance with the

demand for an output lower or higher gear stage of operation.

7.   The Variable Ratio Multi-gear according to claim 3 wherein the first elements are

the ring elements of the respective assemblies, the second rotating elements

comprising of planet carrier elements and planet elements, the planet carrier

15   elements of the respective assemblies constrained to rotate about an axis collinear

with the axes of their respective third elements, the planet elements constrained to

rotate on their own axes with the axes being constrained to rotate with the planet

carrier element, the planet elements with their axes offset from their respective planet

carrier element so as to bridge individually or in combination with other planet

20   elements between the ring element and the third element of their respective

assembly, the planet carrier elements being constrained by a rotation controlling

means allowing free rotation in one direction and a controlled rotation in the other

direction, the third elements of the assemblies being sun elements, the ring and

planet and sun elements being in a form that will allow the transfer of torque at a fixed

25   ratio between elements, the first element of the second assembly constrained to a

fixed frame of reference, a third element of the second assembly rotating at a

controlled angular velocity the control means being operative to progressively

increase or decrease the output gear ratio in accordance with the demand for an

output lower or higher gear stage of operation.

8.   The Variable Ratio Multi-gear according to claim 2 wherein the first elements are the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides being adapted to receive sets of planet elements being in the form of rollers, the second rotating elements comprising of

5   planet carrier elements and planet elements, the planet carrier elements of the respective assemblies constrained to rotate about an axis collinear with the axes of their respective third elements, the planet carrier elements locating and controlling the motion of integral spaced sets of rollers corresponding to the planet elements of each assembly, the rollers bridging between the scallop guides of the outer bodies

10   and the third elements of the assemblies, the planet carrier elements being constrained by a rotation controlling means allowing free rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements in the form of respective cams, the first element of the second assembly constrained from rotating in one direction by a fixed frame of reference and

15   free to rotate in the other direction.

9.   The Variable Ratio Multi-gear according to claim 3 wherein the first elements are the ring elements of the respective assemblies, the second rotating elements comprising of planet carrier elements and planet elements, the planet carrier elements of the respective assemblies constrained to rotate about an axis collinear

20   with the axes of their respective third elements, the planet elements constrained to rotate on their own axes with the axes being constrained to rotate with the planet carrier element, the planet elements with their axes offset from their respective planet carrier element so as to bridge individually or in combination with other planet elements between the ring element and the third element of their respective

25   assembly, the planet carrier elements being constrained by a rotation controlling means allowing free rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements, the ring and planet and sun elements being in a form that will allow the transfer of torque at a fixed ratio between elements, the first element of the second assembly constrained from

rotating in one direction by a fixed frame of reference and free to rotate in the other direction.

10. The Variable Ratio Multi-gear according to claim 2 wherein the first elements are the ring elements of the respective assemblies, the ring elements being outer bodies having spaced endless scallop guides being adapted to receive sets of planet elements being in the form of rollers, the second rotating elements comprising of planet carrier elements and planet elements, the planet carrier elements of the respective assemblies constrained to rotate about an axis collinear with the axes of their respective third elements, the planet carrier elements locating and controlling the motion of integral spaced sets of rollers corresponding to the planet elements of each assembly, the rollers bridging between the scallop guides of the outer bodies and the third elements of the assemblies, the planet carrier elements being constrained by a rotation controlling means allowing free rotation in one direction and a controlled rotation in the other direction, the third elements of the assemblies being sun elements in the form of respective cams, the third element of the second assembly being constrained to rotate at a respective fixed gear ratio relative to an input to the Variable Ratio Multi-gear, the control means being operable to supply a variable rotation to the first element of the second assembly across a continuous range of output gear ratios between low and high angular velocities at respective predetermined low and high output angular velocities.

11. The Variable Ratio Multi-gear according to claim 3 wherein the first elements are the ring elements of the respective assemblies, the second rotating elements comprising of planet carrier elements and planet elements, the planet carrier elements of the respective assemblies constrained to rotate about an axis collinear with the axes of their respective third elements, the planet elements constrained to rotate on their own axes with the axes being constrained to rotate with the planet carrier element, the planet elements with their axes offset from their respective planet carrier element so as to bridge individually or in combination with other planet elements between the ring element and the third element of their respective

assembly, the planet carrier elements being constrained by a rotation controlling

means allowing free rotation in one direction and a controlled rotation in the other

direction, the third elements of the assemblies being sun elements, the ring and

planet and sun elements being in a form that will allow the transfer of torque at a fixed

5   ratio between elements, the third element of the second assembly being constrained

to rotate at a respective fixed gear ratio relative to an input to the Variable Ratio Multi-

gear, the control means being operable to supply a variable rotation to the first

element of the second assembly across a continuous range of output gear ratios

between low and high angular velocities at respective predetermined low and high

10   output angular velocities.

12.   The Variable Ratio Multi-gear according to claim 2 wherein the first elements

are the ring elements of the respective assemblies, the ring elements being outer

bodies having spaced endless scallop guides being adapted to receive sets of planet

elements being in the form of rollers, the second rotating elements comprising of

15   planet carrier elements and planet elements, the planet carrier elements of the

respective assemblies constrained to rotate about an axis collinear with the axes of

their respective third elements, the planet carrier elements locating and controlling

the motion of integral spaced sets of rollers corresponding to the planet elements of

each assembly, the rollers bridging between the scallop guides of the outer bodies

20   and the third elements of the assemblies, the planet carrier elements being

constrained by a rotation controlling means allowing free rotation in one direction and

a controlled rotation in the other direction, the third elements of the assemblies being

sun elements in the form of respective cams, the third element of the second

assembly being constrained to rotate at a respective fixed gear ratio relative to an

25   input to the Variable Ratio Multi-gear, the flow of a suitably formulated fluid or gas or

like due to the action of the first element of the second assembly against a fixed

frame of reference being directed and controlled in two circuits, the flow of said

suitably formulated fluid or gas or like from the said first element of the second

assembly in the first circuit being directed and controlled towards the contracting

spaces on one side of the rollers of the first assembly so as to tend to restrict the

movement of the rollers within the scallops of the first element of the first assembly,

the flow of said suitably formulated fluid or gas or like in the second circuit being

directed and controlled towards a part of the Variable Ratio Multi-gear that provides a

5   low resistance to flow, the progressive control of the amount of flow of the said

suitably formulated fluid or gas or like in the first and second circuits operable to

progressively change the gear ratio applied to a load connected to the first element of

the first assembly of the Variable Ratio Multi-gear.

13.   The Variable Ratio Multi-gear according to claim 10 wherein energy can be

10   transferred to the suitably formulated fluid or gas or like and stored internally or

externally so as to enable the return of the energy to the load when required.

14.   The Variable Ratio Multi-gear according to claim 2 wherein the first elements

are the ring elements of the respective assemblies, the ring elements being outer

bodies having spaced endless scallop guides being adapted to receive sets of planet

15   elements being in the form of rollers, the second rotating elements comprising of

planet carrier elements and planet elements, the planet carrier elements of the

respective assemblies constrained to rotate about an axis collinear with the axes of

their respective third elements, the planet carrier elements locating and controlling

the motion of integral spaced sets of rollers corresponding to the planet elements of

20   each assembly, the rollers bridging between the scallop guides of the outer bodies

and the third elements of the assemblies, the planet carrier elements being

constrained by a rotation controlling means allowing free rotation in one direction and

a controlled rotation in the other direction, the third elements of the assemblies being

sun elements in the form of respective cams, the rotation of the third elements

25   causing motion of the second rotating elements, the motion of the second and third

elements causing contracting and expanding spaces, the contracting spaces in the

first assembly displacing a suitably formulated fluid or gas or like, the displaced fluid

or gas or like being directed into and controlled in two circuits, the control means

proportioning the flow of said suitably formulated fluid or gas or like in the said two

circuits in accordance with the demand for an output lower or higher gear stage of

operation, the flow of said suitably formulated fluid or gas or like in the first circuit

being used to rotate the third element of the second assembly, the flow of said

suitably formulated fluid or gas or like in the second circuit being directed and

5   controlled towards a part of the Variable Ratio Multi-gear that provides a low

resistance to flow, the suitably formulated fluid or gas or like being drawn into the

expanding spaces of the first assembly in a controlled manner after completing the

first or second circuits, the progressive control of the amount of flow of the said

suitably formulated fluid or gas or like in the first and second circuits operable to

10   progressively change the gear ratio applied to a load connected to the first element of

the first assembly of the Variable Ratio Multi-gear.

15.   The Variable Ratio Multi-gear according to claim 12 wherein energy can be

transferred to the suitably formulated fluid or gas or like and stored internally or

externally so as to enable the return of the energy to the load when required.

15   16.   The Variable Ratio Multi-gear according to claim 1 wherein the axis of the input

or inputs are collinear with the axis of the third element of the first assembly, the axis

of the output or outputs are collinear with the axis of the third element of the first

assembly, the axis of the third elements of the first and second assemblies are

collinear, the elements of both assemblies supported directly or indirectly by the fixed

20   frame of reference, the motive source supported directly or indirectly by the fixed

frame of reference, the reactive torque from the motive source acting on the fixed

frame of reference.

17.   The Variable Ratio Multi-gear according to claim 1 wherein the axis of the

inputs are collinear with the axis of the third element of the first assembly, the axis of

25   the output or outputs are collinear with the axis of the third element of the first

assembly, the axis of the third elements of the first and second assemblies are

collinear, the elements of both assemblies supported directly or indirectly by the fixed

frame of reference, a motive source supported directly or indirectly by the fixed frame

of reference and connected to the third element of the first assembly, another motive

source supported directly or indirectly by the fixed frame of reference and connected

to the third element of the second assembly, the reactive torques from the motive

sources acting on the fixed frame of reference.

18.   The Variable Ratio Multi-gear according to claim 1 wherein the axis of the

5   inputs are collinear with the axis of the third element of the first assembly, the axis of

the output or outputs are collinear with the axis of the third element of the first

assembly, the axis of the third elements of the first and second assemblies are

collinear, the elements of both assemblies supported directly or indirectly by the fixed

frame of reference, an input driven by external influences such as wind connected to

10   the third element of the first assembly, another input source driven by external

influences and connected to the third element of the second assembly.

19.   A Variable Ratio Multi-gear having an input and two contra-rotating outputs and

being of the epicyclic type involving interaction of three mechanically distinct rotating

elements with any suitable form that allows the transfer of torque between input and

15   output, namely a sun element, a ring element and a planet element being in each of

at least first, second and third co-axial epicyclic assemblies, a second rotating

element of the first assembly and a second rotating element of the second assembly

being constrained to rotate at a common angular velocity, the first element of the first

assembly and the first element of the third assembly being constrained to rotate at a

20   common angular velocity, and control means for progressively changing the gear

ratio applied to a load connected to the first element of the first and third assemblies

and another load connected to the second element of the third assembly of the

Variable Ratio Multi-gear characterised in that the first and second assemblies each

represent unequal fixed gear ratios respectively between the input and the output of

25   the Variable Ratio Multi-gear the first and second assemblies arranged so that if

individually each assembly has their first element constrained and their third element

rotated in a certain direction the second element will tend to rotate in an opposite

direction relative to the tendency of the other assembly, the third assembly arranged

so that if individually it's first element is constrained and the third element rotated in

the same certain direction of the first and second assemblies the second

element will tend to rotate in the same direction as the second assembly, the

control means being operative to progressively increase or decrease the

output gear ratios in accordance with the demand for an output lower or

5   higher gear stage of operation.

20.   The Variable Ratio Multi-gear according to claim 1 wherein more

elements can be included to provide over-drive and reversing features.

21.   The Variable Ratio Multi-gear according to claim 1 wherein the rotation

controlling and blocking means required, and where over-running

10   requirements are needed can be of any type, such as simple ratchets, one way

clutches, sprag clutches where required and can be reversible, controllable,

releasable, remote controllable, with stepping abilities and can be replaced by

electro-magnetic drives and electro-magnetic fields and clutches, and

hydraulic manipulation, as also with centrifugal clutching of any type, able to

15   be integrated, as well as with liquid polymer control and clutching, these

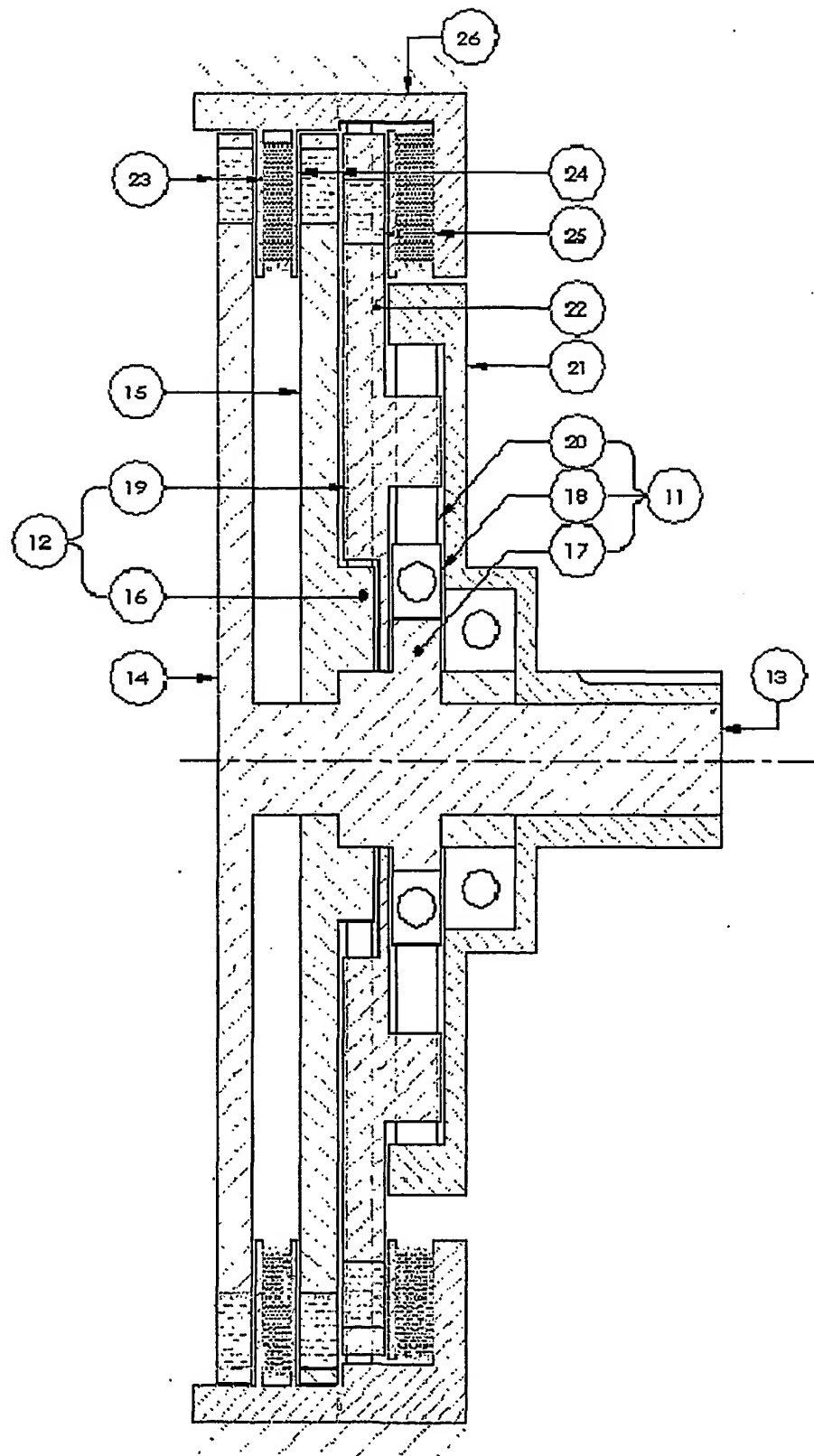being able to operate automatically and with manual over-ride abilities where

chosen.

20

Fig. 1

| A. | CLASSIFICATION OF SUBJECT MATTER |

Int. Cl. [7:]   F16H 3/72, 3/62, 25/06

According to International Patent Classification (IPC) or to both national classification and IPC

| B. | FIELDS SEARCHED |

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: IPC: F16H 3/72, 3/62, 25/06 and keywords: continuous, progressive, infinite, stepless

| C. | DOCUMENTS CONSIDERED TO BE RELEVANT |

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 3861484A (JOSLIN) 21 January 1975 Whole document Whole document	1 2-5
Y	WO 00/17542A (DEAN) 30 March 2000 Whole document	2-5
A	WO 98/20267A (WERRE) 14 May 1998 Whole document	1

| [X]   Further documents are listed in the continuation of Box C | [X]   See patent family annex |

*	Special categories of cited documents:		
"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 2 May 2002	Date of mailing of the international search report 1 3 MAY 2002
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer KURT TOBLER Telephone No : (02) 6283 2469

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5213551A (ANTONOV) 25 May 1993 Whole document	
A	US 4295391A (PHILPOTT et al.) 20 October 1981 Whole document	

C (Continuation).   DOCUMENTS CONSIDERED TO BE RELEVANT

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member					
US	3861484	NONE						
WO	9820267	AU	51005/98	US	5800302			
US	5213551	AU	74784/91	CA	2054740	CS	9100499	
		EP	469145	FR	2658890	US	5409428	
		WO	9113275	FR	2662483			
US	4295391	DE	2921981	GB	1603798			

END OF ANNEX